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CONSTRUCTION MATERIALS BASED ON CULLET

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The results of the development of decorative, heat-insulating and soundproof construction materials based on glass cullet are discussed. The service parameters of the samples are determined and the optimum technological production schemes are developed.

The problem of the rational utilization of glass cullet was always important and is currently becoming especially pressing.

Although the total volumes of glass production in the CIS countries in 1996 decreased to one-third compared to the year 1990, the use of cullet decreased by only 27%, which means that the interest in cullet utilization is growing. However, nobody in Russia and the CIS countries is occupied in sorting of glass cullet which is usually just gathered in heaps. Several factories processing glass into stalinite, mirrors, stained glass and other products ship their high-quality clear cullet not to glass factories but to brick and ceramic plants at negligible prices [1]. Enormous quantities of cullet resulting from bottle, plate, perfume, medical, and other types of glass are dumped in garbage containers and then removed to city dumps. It was found that the content of glass in solid household garbage in Moscow is 4 – 6% [2]. At the same time, the CIS countries have a huge potential for utilization of cullet which is a valuable material resource.

The USA and many western European countries have long been collecting cullet either simply in containers, or in containers transferred from one building to another. This collection and storage system is known as the selective method, which significantly reduces the cost of utilization of cullet for recycled glass or for industrial processing to be used in production of various construction materials [3].

Although this selective system is absent in Russia, Russian scientific publications describe numerous experimental and industrial techniques related to the use of cullet in the production of building materials [4 – 7].

One of the most promising areas of application is the use of glass cullet, both graded and mixed, in the production of heat-insulating and decorative facing materials for construction.

The heat-insulating materials and products are especially important since they concern virtually every aspect of construction technology: quality, cost, and subsequent expenses for maintenance of buildings [8].

It is known that the use of 1 m^2 of thermal insulation saves on the average 1.45 ton of conventional fuel per year, and per capita production of heat-insulating material in the industrially developed countries is 5 – 7 times higher than in Russia [9]. The practice of efficient thermal insulation in western Europe and the USA is based on the application of mineral wool and porous organic materials and composites. However, this experience is not always suitable for Russia due to the high prices of the manufacturing lines produced abroad [10].

The use of organic heat-insulating materials and mineral wool in which phenol alcohols act as binders is restricted for reasons of their combustibility with emission of toxic chemicals, which is inadmissible with respect to environmental safety [11]. Moreover, the biological stability of organic heat-insulating materials leaves much to be desired. These shortcomings are also present in decorative facing materials based on organic compounds.

For the last five years, the researchers in the Department of Glass and Glass-Ceramic Chemical Engineering at Belgorod State Technological Academy of Construction Materials have been researching the development of rational techniques of cullet recycling for various construction materials, implementing the systems analysis of the published data on this subject and studying the problems of designing production lines for cullet concentration to be subsequently used as recycled glass.

Previous publications [12, 13] discussed the results of the experimental studies in the production of glass haydite, porous haydite and cellular glass using recycled cullet from container and sheet glass and picture tubes from the Voronezh Electric Tube Factory together with low-grade

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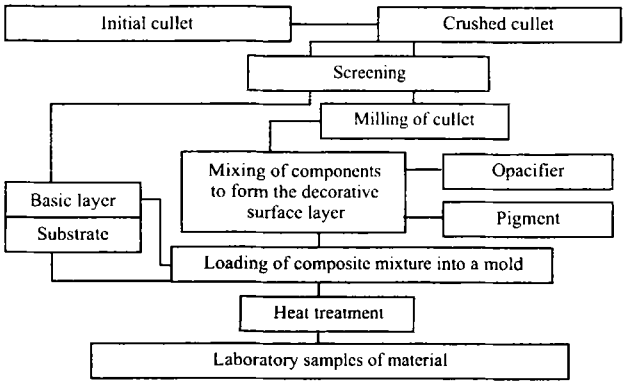
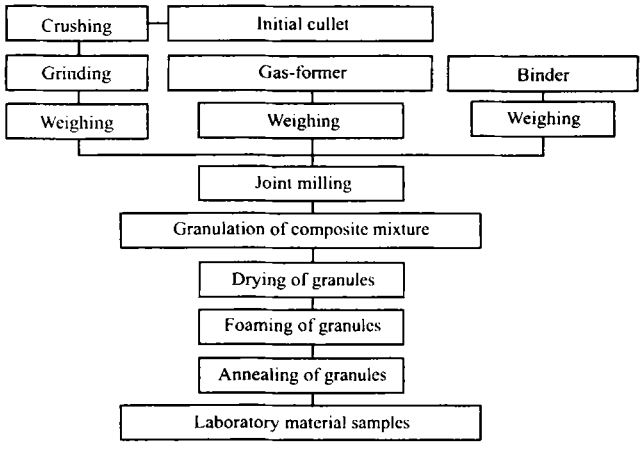
Technological Scheme of Glass Haydite Production



Technological Scheme for Production of Granulated Cellular Glass



quartz sand. The research established the optimum production parameters (specific surface area of the material mixture, time and temperature parameters of sintering and foaming) and the service parameters of samples of the materials.

It should be noted that the use of glass cullet of various chemical compositions in production of vitreous haydite can impart certain specific properties to the material. For example, we developed the material compositions and technological parameters for the production of glass haydite which has a high degree of protection from radioactive radiation. This glass haydite is obtained using the cullet of optical glass (TF-1) and cut glass (PbO content is 18 wt.%) cullet. Three technological schemes were developed and the optimum cost-effective and environmentally safe variant was selected (Table 1).

TABLE 1

Parameter	Glass	
	soundproof	heat-insulating
Volume weight, kg/m^3	250 – 320	240 – 290
Compressive strength, MPa	0.8 – 1.2	0.6 – 0.9
Water absorption, %	1.6 – 2.4	65 – 68
Heat resistance, °C	330 – 390	310 – 360
Linear attenuation factor (E = 42 – 611 KeV), cm^{-1}	0.205 – 0.255	0.108 – 0.195
Energy attenuation ratio (layer thickness 25 mm)	1.7 – 1.9	1.3 – 1.5

Physicomechanical Properties of Protective Glass Haydite

Volume weight, kg/m^3	2900 – 3800
Compression resistance, MPa	21 – 24
Water absorption, %	0.1 – 0.8
True porosity, %	2.0 – 0.8
Linear attenuation factor (E = 42 – 142 KeV) cm^{-1}	2.85 – 5.14
Lead equivalent (layer thickness 1.2 cm), cm	0.304 – 0.384

Glass haydite can be industrially produced in the form of standard sheets (400 × 400, 300 × 300, 300 × 200 and 200 × 200 mm) or an arbitrary-sized sheet, and the cost of setting up such production is accessible even to small companies and private enterprises. Such material can be successfully used in decorative facing for the walls of buildings and structures containing various radioactive sources (nuclear power plants, x-ray diagnostic or flaw detection labs etc.)

The same types of cullet can be used for production of cellular glass which can be used in the above facilities as soundproofing or heat-insulating structural material. The physicomechanical properties of block cellular glass are listed in the table below.

Cellular glass with high chemical resistance which can successfully operate in aggressive environments was obtained based on NS-3 glass cullet. The optimum time-temperature foaming parameters, as well as the type and concentration of gas-forming agents were determined, which makes it possible to obtain cellular glass with a volume weight ranging from 174 to 600 kg/m^3 and compressive strength from 0.3 to 4.3 MPa in laboratory conditions.

Mixed cullet proceeding from container and sheet glass was used to obtain cellular glass in the form of spherical and ellipsoidal granules with rough or vitrified surface. The technological scheme for the production of granular cellular glass was developed.

Physicomechanical Properties of Granular Cellular Glass

Granule diameter, mm	5 – 35
Density, kg/m^3:	
volume density	310 – 380
bulk density	220 – 290
Compressive strength, MPa	3.0 – 7.0
Heat conduction coefficient, W/(m · K)	0.07 – 0.08
Water absorption, %	5 – 7

Several experiments were performed with the aim of obtaining granulated cellular glass with metallurgical slag as a filler. The optimum content of slag in the mixture composition was determined, which does not decrease the volume

mass of the granule but increases their compressive strength by 35 – 40%.

The granulated cellular glass can be widely used as a heat-insulating bulk material and light filler in concretes. The service characteristics of this glass compete successfully with haydite, porous glass haydite and heat-insulated materials such as swelled perlite sand widely used in construction. The production of cellular glass is characterized by environmental safety and availability of material resources.

The cellular glass production line can be equipped with crushing (jaw crushers) and milling (hammer mill, disintegrators, ball mills) units, plate or conical granulators, thermal units for drying, foaming and annealing of granules (slot or revolving dryers, revolving firing kiln, rotary drum firing kilns, mesh annealing furnaces, etc.)

Currently the basic principles of combined technology for cellular glass are being elaborated, which involves cold foaming of crushed glass with foaming agents, molding of articles by casting, drying and subsequent thermal treatment to increase the strength of the product. The advantages of the combined technology are obvious: foam materials of complex configuration can be obtained without a need for metal molds which are traditionally used to produce cellular glass.

The essential requirements imposed on the new types of building materials include both high service parameters and a decrease in production cost and availability of material resources. Therefore, the development of materials for construction and other purposes based on glass cullet and other abundant materials is of great significance.

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